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A Synopsis

On

PHOTOCATALYTIC DEGRADATION OF SOME DYES USING BIMETAL NANOPARTICLES AS PHOTOCATALYSTS

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1. INTRODUCTION

World wide, the concern for environment is growing. Environmental impact of textiles examines what effects do all the phases of textile production and uses have on the environment. Pollution is the main accuse in the textile sector. Millions of tons of various dyes and pigments are produced annually worldwide and used extensively in dyeing and printing industries. It is estimated that about 10% dyes are lost in industrial waste water and pollute the water resources. These dyes are toxic; mutagenic and carcinogenic. The discharge of this colored wastewater into rivers and lakes leads to a reduction in sunlight penetration in natural water bodies, which, in turn, decreases both photosynthetic activity and dissolved oxygen concentration and is, therefore, toxic to living beings.

Untreated effluent from dye stuff production and dyeing mills is objectionable if discharged into open waters. Unlimited and uncontrolled use of such processes can lead to grave consequences in terms of human health and ecological balance. The colored textile effluent needs decolorization invariably prior to its disposal outside environment as per statutory requirement. They cause severe contamination of surface and underground water.

To minimize the environmental impact of textile effluents due to their high coloration and the presence of toxic or carcinogenic dyes, a number of technologies such as electrochemical, precipitation, bio-absorption, bio-oxidation, ozonation, membrane separation processes, physico-chemical treatment and chemical oxidation are available. Semiconductors have been extensively used for their potential of decolorizing textile effluent, in the form of isolated and combined procedures.

The chemical industry is increasingly searching the ways of developing and applying more efficiently and environmentally benign method for treating the dye effluent. The present study is aimed at to remove the dyes under various process conditions from textile waste

water by photochemical oxidation using eco-friendly approach. The work refers to the study of post-treatment (purification) of the textile effluent through photocatalysis using semiconductor which includes the synthesis of some novel photocatalyst and their role in photochemical degradation of synthetic dyes. The main objectives of the present investigation are:

- To synthesize bimetal oxides using cerium (from lanthanum series) and 3d transition metal ions.
- Characterization of synthesized photocatalysts and exploration of its photocatalytic activity in the degradation of some dyes.
- Optimization of the degradation process according to the mass of the semiconductor, treatment time, dye concentration and light intensity.

2. REVIEW OF LITERATURE

Desai et al.[1] reported that dyes are faded by oxidation. Photocatalysis includes such reactions, which utilizes light to activate a substance and modifies the rate of a chemical reaction without being involved. A catalytic reaction involves light absorption by a substrate. The field of photocatalysis has been excellently reviewed by Ali et al.[2] and Singhal et al.[3]. Ahmed et al.[4] reported that the photocatalytic process can mineralize the hazardous organic chemicals to carbon dioxide, water and simple ions.

A composite system of polycrystalline ZnO/TiO_2 and its photocatalytic activity was studied by Marci et al.[5]. Liqiang et al.[6] reviewed the photoluminescence performance of nano-sized semiconducting materials and its relationship with photocatalytic activity. Russo et al.[7] worked on nanometric lanthanum pervoskite type oxides, which act as highly active catalyst for the combustion of diesel soot particles under loose contact conditions.

Choudhary et al.[8] performed carbon free dry reforming of methane to syngas over $NdCoO_3$ pervoskite type mixed metal oxide catalyst. Xie and Yuan[9] reported that a cerium ion plays a role in accelerating photocatalytic reactions.

Although, a number of methods are available for the preparation of nanosized metal oxides; microwave method can produce nanosized particles at relatively low cost (with relatively inexpensive equipments) and in short time. Microwave assisted synthesis of different nanoparticle oxides have been reported by various workers, i.e. $MnFe_2O_4$ (Wang[10]), CuO (Keyson et al.[11]) and Bi_2WO_6 (Wu et al.[12]). $LeCeSrMnO_3$ (LCSMO) coupled microwave assisted ultra fast synthesis of nanocrystalline cobalt oxide and bismuth oxide was carried out by Rajagopal et al.[13].

Zhu et al.[14] synthesized Fe^{3+} doped nanosized TiO_2 photocatalyst by combining sol-gel method with hydrothermal treatment. A new method was developed by Kim et al.[15] to synthesize uniform anatase TiO_2 nanocrystals by the hydrolysis of titanium tetraisopropoxide in nitric acid isopropyl alcohol aqueous solutions at 353 K. Kim et al.[16] used ZnO coated TiO_2 nanoparticles for the flexible dye-sensitized solar cells. Chary et al.[17] characterized and established the reactivity of molybdenum oxide catalysts supported on Nb_2O_5-TiO_2. Nagaoka et al.[18] reported an improvement of Pt/ ZrO_2 by CeO_2 for high pressure CH_4/ CO_2 reforming. Takahashi[19] introduced simple and rapid synthesis of ZnO nanofibre by means of a domestic microwave oven. Controlled synthesis of CuO_2 microcrystal using copper-amine complex under microwave irradiation was reported by Song et al.[20]

Nanosized oxides have proved their efficiency in photocatalytic degradation of dimethoate (Chen et al.[21]), azo dye (Ibhadon et al.[22]), malachite green (Chen et al.[23]], organophosphorus compounds (Rajagopan et al.[24]), chloro-, fluoro-, bromocarbons and sulfur compounds (Decker et al.[25]).

Sun et al.[26] studied photocatalytic degradation and kinetics of orange-G using nanosized Sn (IV) TiO_2 as a photocatalyst. Akpan et al.[27] studied effects of operating parameters on the photocatalytic degradation of textile dyes using TiO_2-based photocatalyst. Mittal et al.[28] tried batch and bulk removal of fast green FCF from wastewater by adsorption over de-oiled soya and bottom ash, which are agricultural waste and power plants waste, respectively. Various researchers investigated the degradation of fast green dye using *Azadirachta indica* (neem) leaf powder (Tahir et al.[29]), electrogenerated Fenton reagent at carbon-felt cathode (Sires et al.[30]), aqueous suspension of titanium dioxide under a variety of conditions (Saquib et al.[31, 32]) and ZnO (Bhandari et al.[33]) as photocatalysts.

Photocatalytic degradation of acid blue-62 over CuO-SnO_2 nanocomposite photocatalyst under simulated sunlight has been reported by Xia et al.[34] Use of semiconducting ions (III) oxide in photocatalytic bleaching of some dyes has been reported by Ameta et al.[35] Photocatalytic degradation of brilliant red dye and textile waste water has been observed by Martins et al.[36]. ZnS-CdS catalysed photocatalytic bleaching of malachite green and brilliant green dyes has been investigated by Gandhi et al.[37] The photocatalytic bleaching of some dyes (eriochrome black-T, methylene blue and malachite green) was carried out in the presence of semiconducting zirconium phosphate by Pawar et al.[38] Photocatalytic degradation of cetylpyridinium chloride over TiO_2 has been reported by Singhal et al.[3]. Similar photocatalytic reaction of xylidine ponceau and orange-G dyes by ZnO powder has been reported by Sharma et al.[39]. Yoneyama et al.[40] studied the photocatalytic reduction of dichromate ions using WO_3 powder in acidic range. Shyama and Arakawa[41] have used zirconium dioxide as photocatalyst. The effect of TiO_2 acidic pre-treatment on the photocatalytic phenol degradation was reported by Colon et al.[42]. Enhanced efficiency of unsymmetrical versus symmetrical squaraine dyes sensitized nanocrystalline TiO_2 was

reported by Alex et al.[43]. Morwetz and Selli[44] investigated the effect of iron species in photocatalytic degradation of azo dye in TiO_2 suspension.

3. METHODOLOGY

The material used for the preparation of bimetal oxides are lanthanum sulphate $[La(SO_4)_4.4H_2O]$ and the ions of some 3d transition metals like Cu^{2+}, CO^{2+}, etc. First of all, lanthanum sulphate $[La(SO_4)_4.4H_2O]$ and the metal ion solutions will be mixed. Under gentle stirring, the pH will be slowly raised to around 10 by the addition of NaOH solution. After 10 hours stirring, the suspension will be repeatedly washed and the residue will be dried at 100°C for 10 hours. Now, bimetal oxide will be irradiated under microwave conditions for few minutes. The catalyst so synthesized will be characterized on the basis of physical, chemical, analytical and spectral data and will be used for the photocatalytic degradation of some dyes.

4. SIGNIFICANCE OF RESEARCH WORK

The active ingredients currently being used as catalyst in the catalytic converters in developed countries are noble metals such as Pt, Pb, Rh etc. The search for newer catalysts as a substitute for these noble metals is under a pressing demand as these metals are very costly and rare. The alternative catalysts for these noble metals may be in the form of mixed metal oxides which have been given moderate attention. Other possible alternative catalysts are nanoparticles sized bimetal catalysts. The use of nanosized catalyst is more advantageous, since, it provides greater surface area and therefore, accelerated rate of reactions. The role of nanoparticles bimetal oxides in the treatment of polluted water will be a step towards the most demanding stream of the day, that is, "green chemistry".

Photocatalysis provides a cleaner and environmentally benign method for waste water treatment.

The photochemical approach will help in reducing the environment pollution caused by textile industries. There is a possibility of utilizing the treated water after recycling for cleaning, washing, cooling of steam based projects (power plants), irrigation etc.

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